Geophysical Research Abstracts
Vol. 15, EGU2013-6078-1, 2013
EGU General Assembly 2013

A theoretical model of sheath fold morphology in simple shear

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Sheath folds are highly non-cylindrical structures often associated with shear zones. The geometry of sheath folds, especially cross-sections perpendicular to the stretching direction that display eye-patterns, have been used in the field to deduce kinematic information such as shear sense and bulk strain type. However, how sheath folds form and how they evolve with increasing strain is still a matter of debate.
We investigate the formation of sheath folds around a weak inclusion acting as a slip surface in simple shear by means of an analytical model. We systematically vary the slip surface orientation and shape and evaluate the impact on the evolving eye-pattern. In addition we compare our results to existing classifications.
Based on field observations it has been suggested that the shear sense of a shear zone can be determined by knowing the position of the center of an eye-pattern and the closing direction of the corresponding sheath fold. In our modeled sheath folds we can observe for a given strain that the center of the eye-structure is subject to change in height with respect to the upper edge of the outermost closed contour for different cross-sections perpendicular to the shear direction. This results in a large variability in layer thickness, questioning the usefulness of sheath folds as shear sense indicators. The location of the center of the eye structure, however, is largely invariant to the initial configurations of the slip surface as well as to strain.
It has been suggested that the ratio of the aspect ratio of the innermost and outermost closed contour in eye-patterns could be linked to the bulk strain type based on filed observations. We apply this classification to our modeled sheath folds and we observe that the values of the aspect ratios of the closed contours within the eye-pattern are dependent on the strain and the cross-section location. The ratio (R') of the aspect ratios of the outermost closed contour (Ryz) and the innermost closed contour (Ry'z') shows values above and below 1. We can show that R' is dependent on the slip surface size and orientation but not on the number of involved contours.
Our model results suggest that the morphology of sheath folds can not be easily linked to a specific shear sense or bulk strain type and that great care has to be taken when interpreting sheath folds in nature.